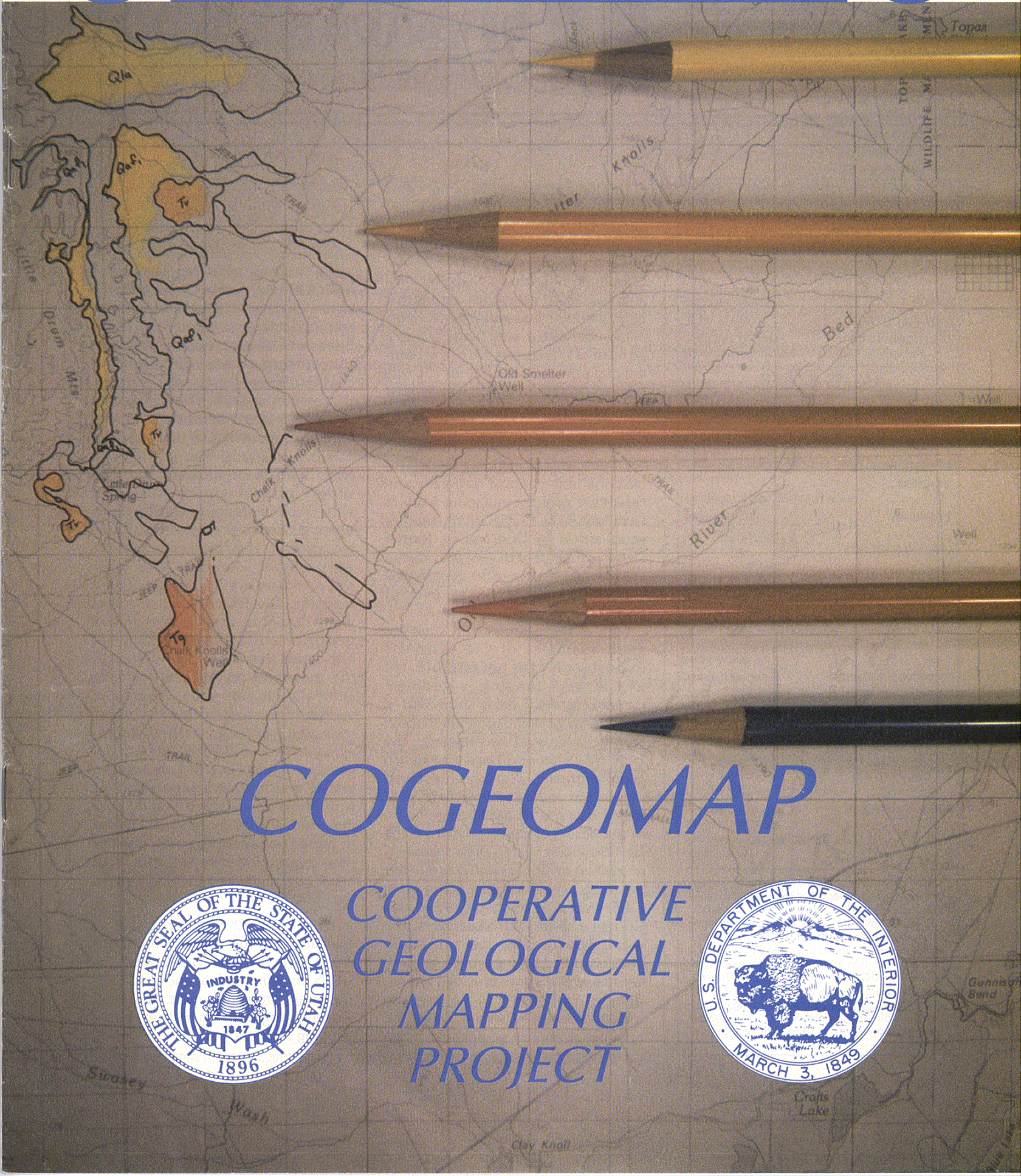
SURVEY NOTES

VOL. 21 NO. 2-3 SUMMER/FALL 1987

UTAH GEOLOGICAL AND MINERAL SURVEY



COGEOMAP

COOPERATIVE GEOLOGICAL MAPPING PROJECT

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Cover design by Julia Vigil.

Survey Notes is published quarterly by **Utah Geological and Mineral Survey**, 606 Black Hawk Way, Salt Lake City, Utah 84108 (801) 581-6831. The UGMS inventories the geologic resources of the state, identifies its geologic hazards, disseminates information concerning Utah's geology, and advises policymakers on geologic issues. The UGMS is a division of the Department of Natural Resources. Single copies of Survey Notes are distributed free of charge to residents within the United States and Canada. Reproduction is encouraged with recognition of source.

FROM THE DIRECTOR'S CORNER

This issue of *Survey Notes* highlights the United States Geological Survey/Utah Geological and Mineral Survey cooperative effort funded under a program called COGEOMAP: Cooperative Geologic Mapping Project. Just about everybody agrees that basic geologic and geophysical information benefits a wide range of users. As most of these users are of the opinion that others should pay for it, USGS created COGEOMAP as a way to fund basic geologic and geophysical studies jointly with state geological surveys.

In the lead article, Jack Oviatt and Fitz Davis, UGMS mapping geologists, describe the national program and report on geologic mapping work in Utah funded by COGEOMAP. Another short article by Don Mabey, former Deputy Director of UGMS, provides an update on the status of the geophysical work done by USGS as part of COGEOMAP.

Both of these projects in Utah are good examples of COGEOMAP's importance. To be eligible for COGEOMAP funding, a geologic mapping project must show that it considers a geologic problem that can best be addressed by mapping. The work by Oviatt and Davis in western Utah addresses a great unresolved problem in understanding Utah's geologic history: what has been going on in the basins of western Utah for the last 15 million years? Their mapping project bit off only a small piece of this dilemma...what has been going on in the Sevier Lake/Delta/Millard and Juab Counties' basins for the last few million years. By addressing this gap in our understanding of Utah's geologic past, Oviatt and Davis have provided a multipurpose map that can be used by industry interested in sand, gravel and road metal, and for geotechnical consultants interested in the type and depth of surficial materials that can affect construction costs and the availability of water resources.

Utah's geophysical project funded by COGEOMAP is providing a uniform, statewide data set of magnetic, gravity and radiometric information. These three sets of geophysical maps and supporting data sets will be a major contribution of basic earth science information in Utah. The digital data sets can be used to construct profiles and contour maps at scales from 1:24,000 upwards. The gravity and magnetic data will be useful in a wide variety of geologic investigations either independently or together with other geophysical studies of subsurface geology. Their most important use will be when integrated with other data including basic geologic mapping. Gravity and magnetic data alone cannot be used to infer unique geologic models of the subsurface, but any model that is not consistent with the measured gravity and magnetic anomalies is not valid. Computer methods are now available to convert measured gravity and magnetic anomalies into two- and three-dimensional geologic models and to compute the gravity and magnetic anomalies that would be produced by two- and three-dimensional geologic models. The use of these computer programs with the new geophysical data sets can make major contributions to geologic investigations in Utah.

The COGEOMAP program is another example of a cooperative effort between the UGMS and the USGS enabling both agencies to carry out their programs more effectively working together than they could working separately.

COGEOMAP

By Charles G. (Jack) Oviatt[1] and Fitzhugh D. Davis[2]

INTRODUCTION

COGEOMAP refers to a program of Cooperative Geologic Mapping designed to support basic and applied geologic mapping by state geological surveys and the U.S. Geological Survey (USGS). The program was initiated by the USGS in 1985 with one million dollars in appropriations, and in 1986 the total program budget was $1.5 million. In 1985, 21 mapping projects in 18 states were funded, and in 1986 the costs of 31 projects in 29 states were covered. The key to the success of the program is its cooperative nature; the USGS and the state surveys share the costs of geologic studies. In most cases the USGS share has consisted of cash, and the state shares have consisted of services in kind, although in some cases the USGS has provided part or all of its share as services in kind. COGEOMAP is now in its fourth year, and Utah has participated in the program for the years 1986 and 1987. Through COGEOMAP, the Quaternary geology of parts of Utah previously not mapped in detail is being documented in a comprehensive way for the first time.

In general, COGEOMAP projects throughout the United States have been aimed at obtaining basic geologic information that can be used in studies of mineral or energy resources, geologic hazards, or geologic engineering. Geologic maps are fundamental sources for most geologic investigations, and state geological surveys must have a broad data base available for making reliable and some times quick assessments or decisions. COGEOMAP was designed to help fill the gaps in the geologic information base of many states, or in some cases to replace old information with new interpretations that have grown out of the explosion of ideas and new perspectives in the earth sciences during the last 30 years.

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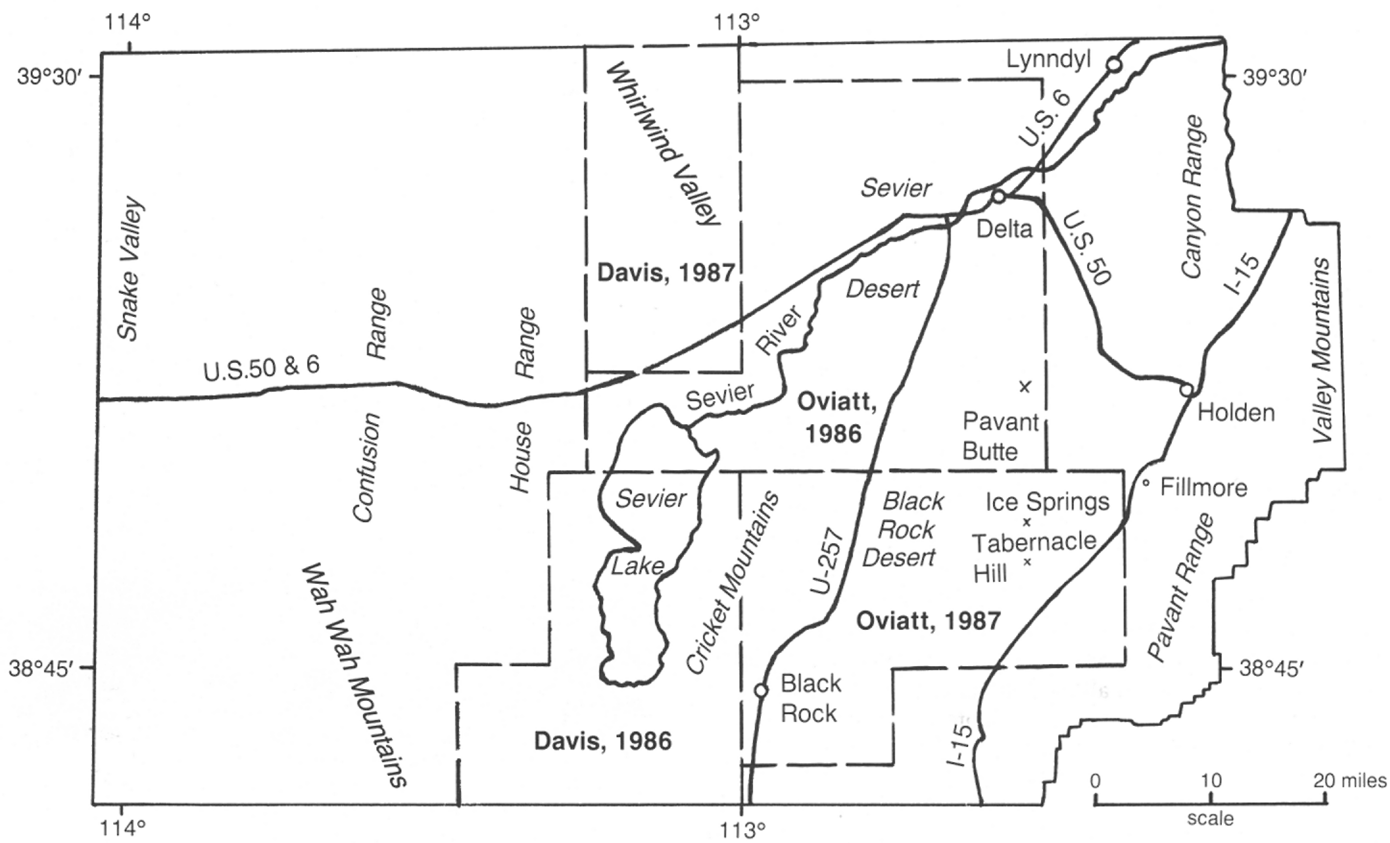


Figure A. Index map of Millard County showing COGEOMAP study areas by Oviatt and Davis.

Therefore, the first priority of COGEOMAP is to promote mapping projects that will result in large- to intermediate-scale maps of areas that have been identified as important by state surveys or by the USGS. These projects are more than simply compilations of existing data - they represent the collection and synthesis of new geologic information at scales of 1:24,000 to 1:100,000. Many COGEOMAP projects involve mapping of 7.5-minute or 15-minute quadrangles, and therefore represent significant advances in the geologic knowledge of small areas.

Examples of these first-priority COGEOMAP projects include Wyoming's mapping (at 1:24,000) in an area along the southeastern margin of the Bighorn Mountains that previously was not well mapped but which is an important recharge area for bedrock aquifers and has potential for oil or tar sand development. Other nearby states with COGEOMAP projects involving large-scale mapping include Nevada, which is mapping the geology in the Reno area in detail, and Arizona, which is mapping the Phoenix 1° X 2° quadrangle in a series of 1:24,000 maps. In addition, many other states, including Utah (discussed below), have large-scale mapping projects underway.

The second priority of COGEOMAP is to support regional mapping at scales of 1:250,000 or smaller. In some states, such as New Mexico, South Dakota, Virginia, and New Jersey, new state geologic maps are being produced. Mapping at 1:250,000 often fills gaps in knowledge that are encountered during the compilation of the state maps.

COGEOMAP's third priority is to support the compilation of digital geophysical maps and digital geophysical data. The USGS provides all the funds for the geophysical maps. The maps include gravity, magnetic, and radiometric maps, and have been or are being compiled for Ohio, Nevada, Idaho, Montana, New Mexico, Arizona, Colorado, and Utah (see Don Mabey's article on geophysical mapping).

Funding for COGEOMAP mapping projects has ranged from $583,000 for detailed and regional mapping in New Jersey to $18,000 for 7.5-minute quadrangle mapping in Vermont. Utah's 1986 COGEOMAP budget totaled $60,000, half of which consisted of cash from the USGS, and the other half of in-kind services provided by the Utah Geological and Mineral Survey (UGMS). Utah ranked 13th in total funding out of the 29 states that participated in COGEOMAP projects in 1986.

COGEOMAP PROJECT IN UTAH

Introduction

Utah's COGEOMAP geologic mapping projects have focused on mapping Quaternary deposits in western Utah. In 1986, large areas in the central part of the Sevier desert and around Sevier Lake were mapped at a scale of 1:100,000 (figure A). During the summer of 1987, this mapping was extended south into the Black Rock Desert and west into the Long Ridge and Whirlwind Valley areas. A map and report are now in preparation for the Black Rock Desert. For 1988, the Quaternary geology of Fish Springs Flat in Juab County will be mapped at a scale of 1:24,000. In all of these cases, efforts have been concentrated on subdividing the Quaternary deposits to the greatest possible extent, given the constraints of map scale and time, in order to better understand the area's geologic history.

Of the many possibilities for COGEOMAP mapping in the state of Utah, the mapping of Quaternary deposits in western Utah was chosen for the following reasons:

1. Quaternary deposits cover more than half of the Basin and Range physiographic province of western Utah and may attain great thicknesses in the extensional tectonic basins in this region. Despite this areal extent, most previous mapping has emphasized only the bedrock geology, and the Quaternary deposits have been lumped into one or several broad map units that do not reveal their complexity or significance. Therefore, the geology of a large part of western Utah is known at no better than a reconnaissance level.

2. Quaternary deposits are important aquifers for fresh water in western Utah, including aquifers in the urban centers along the Wasatch Front as well as in the agricultural areas near Delta and Fillmore. Therefore, it is important to understand the distribution, history, and character of the Quaternary deposits.

3. The deposits of Lake Bonneville, which are important for a number of reasons, are being studied in detail in COGEOMAP projects. Lake Bonneville covered 20,000 square miles of western Utah, and parts of Nevada and Idaho, including the COGEOMAP map areas and areas now occupied by Wasatch Front cities. An understanding of Lake Bonneville stratigraphy, geomorphology, and history has proved to be essential in neotectonic studies in Utah, including studies of paleoseismicity and isostatic rebound. In addition, Lake Bonneville is one aspect of the paleohydrology of the Great Salt Lake and Sevier Lake basins, both of which have experienced high water levels in recent years.

4. The paleohydrology of the last few thousand years has a direct bearing on attempts to predict the future fluctuations of the Great Salt Lake and Sevier Lake. In COGEOMAP projects, the deposits of the lakes and their tributary streams are mapped and dated, thus adding to the information base of hydrologic changes over long time scales in these basins.

5. In addition to the potential earthquake hazards in Utah, volcanic hazards are also present, although they are significantly less severe. The Black Rock and Sevier Deserts each have a long history of volcanic eruptions spanning the late Tertiary and Quaternary Periods. The Ice Springs cinder cones and lava flows were erupted about 700 years ago, while Pavant Butte and Tabernacle Hill were erupted 16,000 and 13,500 years ago, respectively. Although any new eruptions from these, or nearby volcanic vents, are unlikely to cause extensive destruction except in the immediate vicinity of the eruptions, they are geologic hazards with a high probability of recurrence, and we need a better understanding of the past volcanic activity to assist in predictions of future eruptions.

Figure B. View of Pavant Butte from the south. The altitude at the base of the volcano is about 4750 feet, and the summit is 5751 feet. The Bonneville Shoreline is visible about halfway up the side of the volcano. Pavant Butte was erupted into Lake Bonneville when the lake was within 50 feet of the Bonneville Shoreline.

Quaternary map units in COGEOMAP projects

In COGEOMAP projects we have used a system of Quaternary map units that combines genetic, descriptive, and in some cases, relative-age information in a series of concise map-unit symbols. The format for the map-unit scheme was suggested by James P. McCalpin of Utah State University and was refined and expanded by Oviatt and others at the UGMS for use in the UGMS 7.5 minute geologic quadrangle mapping program. The system provides a framework with some fairly rigid rules for consistency, but it is flexible enough to accomodate newly recognized units or deposits that are unique to relatively small areas and that have special geologic significance.

Two or three properties of a Quaternary deposit are considered in classifying it for mapping purposes. First, the depositional environment is identified. In the map symbol, the first letter is an upper-case Q, and the second letter indicates depositional environment. In Utah, the most commonly encountered Quaternary depositional environments are alluvial (a), lacustrine (l), eolian (e), glacial (g), and mass wasting (m), and most surficial deposits can be broadly categorized into one of these. In cases where the depositional environment is unclear, or where more than one is involved, an appropriate unused letter is chosen.

The third letter in the map-unit symbol describes some distinguishing characteristic of the deposit. In some cases, the texture of the deposit is specified; for example, lacustrine sand would be mapped as Qls, and alluvial mud as Qam. In other cases, the geomorphology of the deposit is indicated. Some examples are Qaf for alluvial fan, and Qed for eolian dunes.

The relative ages of deposits are indicated by number subscripts. Deposits having similar lithology, texture, or morphology, but different ages, are indicated with similar letter symbols but the youngest deposit is designated number one (1) and older deposits are given larger number subscripts. For example, of three alluvial fan deposits having different ages, Qaf_1 is the youngest, and Qaf_3 is the oldest.

Thus the map symbols provide information on the kinds of geologic processes that are operating in a map area and the relative ages of the deposits. From this the geologic history, general engineering properties, susceptibility to geologic hazards, or other aspects of the deposits can be inferred. Therefore, the Quaternary map-unit system conveys a great deal of information with simple, concise notation, and is a vast improvement over mapping all Quaternary deposits as "Qal."

Figure C. Vertical aerial photograph of an area on the western slope of the Cricket Mountains showing typical Quaternary deposits in the Sevier Desert. A = Sevier Lake playa; B = late Holocene gravel beaches; C = Lake Gunnison shoreline; D = exposures of the white marl (deep-water deposits of Lake Bonneville); E = wave-washed alluvial fans; F = fine-grained pre-Lake Bonneville lacustrine deposits of late Tertiary to Quaternary age; G = sand composed largely of calcium carbonate deposited below the Provo shoreline; H = pre-Lake Bonneville alluvial fans; I = Paleozoic sedimentary rocks in the Cricket Mountains; J = Provo shoreline; K = lacustrine sand deposited over wave-washed alluvial fans; L = bay-mouth gravel barrier at the Bonneville shoreline; M = erosional notch at the Bonneville shoreline; N = Quaternary.

Mapping in the Sevier Desert and Black Rock Desert

In 1986 Utah's COGEOMAP efforts got underway with mapping projects in the Sevier Desert and Sevier Lake areas. In 1987 the mapping was extended south into the Black Rock Desert and west into the Long Ridge and Whirlwind Valley areas (figure A). These areas together contain some of the most extensive exposures of Quaternary deposits in the State of Utah, and they had not been previously studied in a comprehensive way. With COGEOMAP the Quaternary deposits have now been mapped at a scale of 1:100,000, and the Quaternary history of the area has been outlined, even if only at a reconnaissance level.

Surficial deposits in the COGEOMAP map area consist of fine-grained lacustrine deposits of Lake Bonneville and pre-Bonneville Quaternary lakes, vast areas of fine-grained alluvium, and coarser-grained lacustrine and alluvial deposits in piedmont areas. Thin deposits of eolian sand or silt and clay are present throughout the map area and are concentrated in dunes in favorable localities. Altogether, twenty Quaternary symbols have been used to map these deposits. The map area also contains Quaternary basalt flows and volcanic vents, and silicic volcanic rocks of late Tertiary age. Quaternary faults cut deposits of all ages

In addition to basic geologic data, important new details of the Quaternary geology of the Sevier Desert and Black Rock Desert areas have been obtained through the COGEOMAP projects. These can be summarized as: 1) new information on the history of Lake Bonneville; 2) new information on the post-Bonneville history of Sevier Lake; 3) new information on the post-Bonneville history of sedimentation along the lower Sevier River; and 4) new information on the history of Quaternary volcanic eruptions in the Black Rock Desert. Each of these is described briefly below.

Despite the century of research on Lake Bonneville that began with G. K. Gilbert, the geomorphology, stratigraphy, isostatic rebound, and history of Lake Bonneville are still being studied and refinements are being made. Some significant new clues to the complex story of Lake Bonneville have been discovered during COGEOMAP projects. The Sevier Desert basin was an arm of Lake Bonneville at stages higher than the Stansbury shoreline, and an excellent geologic record of the lake is preserved in the basin. Shore-zone gravel and sand, major deltaic sequences at the mouths of the Sevier and Beaver Rivers, and deep water marl deposits (the white marl of G. K. Gilbert) are some of the facies that have been mapped. When the physical stratigraphy of the deposits is studied in conjunction with the fossil record of mollusks, ostracodes, and plants, and the deposits are dated or correlated based on radiocarbon methods, amino-acid studies, or volcanic ashes, fine details of the lake history can be documented. Mapping is the first and necessary step in such studies, and COGEOMAP has provided the means to accomplish this step.

As the result of COGEOMAP, we now know that Lake Bonneville first began to overflow into the Snake River drainage in southern Idaho shortly after 14,500 years ago, which is 1500 years younger than previous estimates of this event. The beginning of overflow is important because it marks the beginning of development of the Bonneville shoreline, the highest shoreline in the basin. The shoreline is a prominent geomorphic marker in the Bonneville basin and its age is critical in many studies of paleohydrology, isostatic rebound, and paleoseismicity. In addition, the age of the Bonneville shoreline constrains the age of the Bonneville flood and the Provo shoreline, which have not been well dated. Thus, both the Bonneville flood, which was the catastrophic release of all the water between the Bonneville shoreline and the Provo shoreline due to the failure of the alluvial dam near Red Rock Pass, Idaho, and the development of the Provo shoreline, occurred after the Bonneville shoreline had formed.

COGEOMAP studies have disclosed new data, including stratigraphic information and radiocarbon dates, on the post-Lake Bonneville history of Sevier Lake. After about 12,000 years ago, during the regressive phase of Lake Bonneville, the lake split into two smaller lakes in separate basins. The lake in the Sevier Lake basin, which is called Lake Gunnison, was shallow and fresh, and overflowed into the saline lake in the Great Salt Lake basin from about 12,000 years ago until 10,000 years ago. After that, Lake Gunnison ceased to overflow, and the Sevier Desert began to dry out.

Figure D. View south along the northwestern shore of Sevier Lake showing a gravel barrier-beach in the foreground, with a wooden pole resting on its crest. This beach was deposited in 1984 and 1985 during the recent high stand of Sevier Lake, and has closed off the mouth of a small ephemeral stream that used to empty into Sevier Lake. The photo was taken in July, 1986, after the lake had dropped several feet from its 20th century high. The wooden pole is about 8 inches in diameter.

During the early and middle Holocene, Sevier Lake probably stayed at low levels comparable to levels of the historic lake, but during the late Holocene the lake rose to relatively high levels. The highest late Holocene transgression was between about 3000 and 2000 years ago, and a series of high stands occurred during the last 500 years. In 1985 Sevier Lake attained its highest level since G. K. Gilbert observed it in 1872. From 1880 until 1983, Sevier Lake was dry except for thin films of water on the surface of the playa during unusually wet years. Therefore, through COGEOMAP the first complete summary of the Holocene history of Sevier Lake has been made possible. It is interesting to note that the late Holocene fluctuations of Sevier Lake were similar in timing and magnitude to those in the Great Salt Lake.

Alluvium of the Sevier River in the vicinity of Delta, Utah, is very important to the agricultural industry in that area. Hundreds of archaeological sites indicate that the Sevier River and its "delta" have been attractive resources to humans for a long time. As the result of COGEOMAP the post-Bonneville history of the Sevier River downstream from the town of Delta is now known with much more detail than before. Geomorphic studies for archaeological investigations in the Sevier Desert had outlined the alluvial stratigraphic sequence at specific sites, but COGEOMAP provided the means to tie together those interpretations into a coherent story for much of the area. In addition, a number of new radiocarbon dates on alluvial materials have been obtained. Much work needs to be done, but there is potential in this area for future paleogeomorphic investigations, including studies of the relationship between the changing levels of Sevier Lake and the behavior of the Sevier River, and studies of pre-settlement flooding of the river.

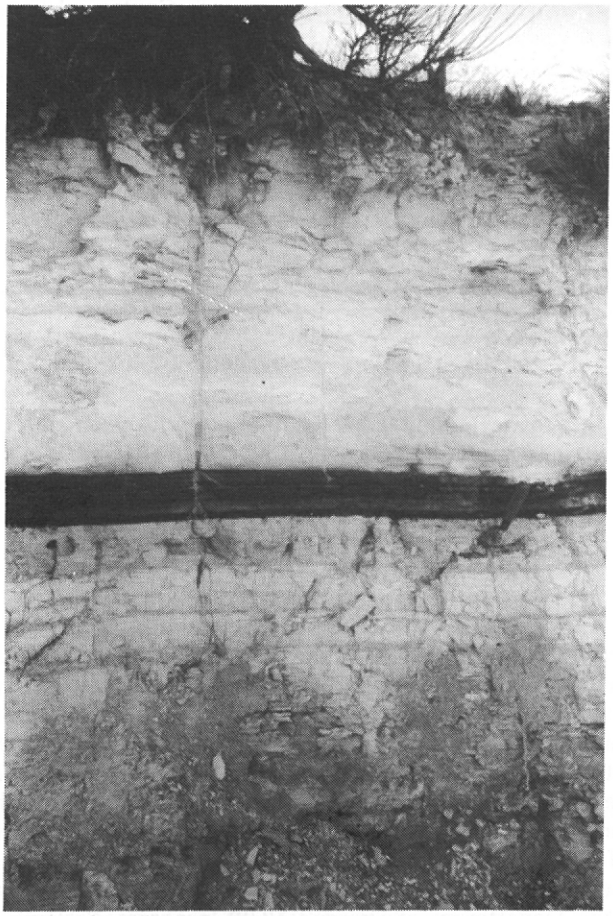


Figure E. Pavant Butte basaltic ash interbedded with deep-water sediments (the white marl) of Lake Bonneville. This exposure is in an abandoned canal that crosses Utah Highway 100 a few miles west of Fillmore. The Pavant Butte ash is found within the white marl at many localities in the Sevier Desert. At this locality, 12 miles downwind from Pavant Butte, the ash is 4 inches thick.


Figure F. Basaltic pillow on the east side of the Tabernacle Hill basalt flow. This lava flow was erupted into Lake Bonneville at or slightly below the Provo shoreline. Note the concentric zoning within the pillow, which was caused by rapid cooling of the lava surface in the lake water. Tufa, which was precipitated in the wave zone of the lake, is encrusted on the basalt (above and to the right of the pillow).

Finally, the eruptive history of two volcanoes in the Black Rock Desert has been accurately determined in COGEOMAP projects. The two volcanoes are Pavant Butte and Tabernacle Hill, both of which are basaltic tuff cones, and both were erupted into Lake Bonneville. Pavant Butte was erupted into the lake when the lake was within 50 feet of its highest level during its transgressive phase. This has been determined through mapping at the tuff cone itself and by tracing the fine-grained tephra or ash that was produced by the eruption and that is found interbedded with Lake Bonneville deposits at many localities in the Sevier and Black Rock Deserts. The highest known exposure of Pavant Butte ash is in shore-zone deposits about 50 feet below the Bonneville shoreline southwest of Kanosh, Utah, and a radiocarbon date associated with the ash suggests that the eruption occurred about 16,000 years ago.

Tabernacle Hill tuff cone rests on top of a basaltic lava flow, both of which were erupted into the lake. Basaltic pillows and calcareous tufa on the outer margin of the lava flow indicate that it was erupted into the lake at or slightly below the Provo shoreline. The Tabernacle Hill ash is much less extensive than the Pavant Butte ash, but it too is found interbedded with the fine-grained Lake Bonneville deposits near the volcano and below the Provo shoreline. The eruption that produced the Tabernacle Hill tuff cone and lava flow probably occurred about 13,500 years ago, based on its association with the Provo shoreline.

We have summarized some of the most valuable new geologic facts that have been discovered on COGEOMAP projects in Utah. However, of equal importance is the vast amount of basic information that is compiled on the geologic maps and available for many different uses. Geologic maps are fundamental tools of geology and many related disciplines of earth science. COGEOMAP is a great opportunity for the State of Utah to gain new geologic information in areas that previously have been poorly understood.

COGEOMAP in 1988

For 1988 COGEOMAP the UGMS has proposed to continue mapping Quaternary deposits in western Utah. Specifically, the Quaternary geology of Fish Springs Flat in western Juab County will be mapped at a scale of 1:24,000. In this project one of the main objectives is to refine the system of Quaternary map units further so that certain aspects of the deposits can be shown in great detail. For example, such things as the relationships between the Quaternary deposits and bedrock source areas, gradual changes in texture, lithology, or geomorphic expression within individual units, or changes in depositional patterns through time might have important applications and attempts will be made to depict them at a large scale. Fish Springs Flat is a good area to experiment with highly detailed mapping because of the diversity of bedrock lithologies in the surrounding mountain ranges, thus permitting sediments to be traced directly to their sources. In addition, a fairly complete record of Lake Bonneville lacustrine deposits and post-Bonneville alluvial and eolian deposits is preserved. Potential applications of detailed map information in Fish Springs Flat include studies aimed at understanding such things as the sedimentation mechanisms on alluvial fans, the transport of sediment in lacustrine currents or by wind, the transport and deposition of placer deposits, the movement and occurrence of ground water in a desert basin, and the structural development of a typical basin in the Basin and Range physiographic province. Therefore, we foresee continued success for COGEOMAP in Utah in the near future.

REFERENCES

Oviatt, C. G., 1987, Quaternary geology of part of the Sevier Desert, Millard County, Utah: Utah Geological and Mineral Survey Open-File Report 106.

Oviatt, C. G., in preparation, Quaternary geology of the Black Rock Desert, Millard County, Utah: Utah Geological and Mineral Survey Open-File Report.

Reinhardt, J., and Miller, D. M., 1987, COGEOMAP: A new era in cooperative geologic mapping: U.S. Geological Survey Circular 1003, 12 p.

COGEOMAP Update on Geophysical Maps

by Don R. Mabey

The complete Bouguer gravity map, which is nearly finished, is based on approximately 46,000 gravity stations established by many individuals and organizations. Much of the data is being supplied by Dr. Kenneth L. Cook from the files of the University of Utah, Department of Geology and Geophysics. The data is being processed by Vickie Bankey of the USGS and the map is being edited by Dr. Cook and myself. The gravity map will be published by the UGMS at a scale of 1:5000,000 (the same scale as the state geologic map). Computer files containing the principal facts of the gravity stations will be able to be accessed by the public after the publication of the complete Bouguer anomaly map. The USGS plans to publish several 1:1,000,000 scale maps based on this data set including isostatic and derivative maps.

A magnetic map is also being compiled by Vickie Bankey using data from numerous airborne magnetometer surveys flown by or for the USGS and the Department of Energy (DOE). The magnetic data will be adjusted to a common datum, projected to a single elevation, and presented as a total intensity residual map. As with the gravity map, the UGMS will publish a 1:500,000 scale map, the USGS will publish 1:1,000,000 derivative maps, and the digital data set will be available to the public. Plans are for the magnetic map to be completed in 1988.

The gamma-ray radiation maps are being compiled by Joseph Duval of the USGS from airborne surveys flown as part of the Department of Energy's NURE program. Preliminary versions of this map are being used by Doug Sprinkel (UGMS) in studies of radon hazards for Utah's Department fo Health but the final version of the map is not expected for about two years. Publication plans for these radiation maps have not been finalized.

THE END OF THE WET CYCLE

By Don R. Mabey

The wet cycle in northern Utah that began in 1982 ended in 1986. Precipitation at the Salt Lake City International Airport for the water year ending September 30, 1987, was 70 percent of the 30-year average. Stream flows and soil moisture in northern Utah are near or below average and Great Salt Lake has stopped rising. If much above normal precipitation occurs in subsequent years, it can logically be considered a new cycle.

Much above normal precipitation in this the 1982-1986 cycle was responsible for hundreds of millions of dollars damage from landslides, stream flooding, ground-water rises and the rise of Great Salt Lake, Utah Lake and Sevier Lake. The National Weather Service and the news media, with understandable enthusiasm to report new records based on relatively short periods of observation, may have conveyed the impression that the cycle of wet weather is unprecedented in history. This is not true.

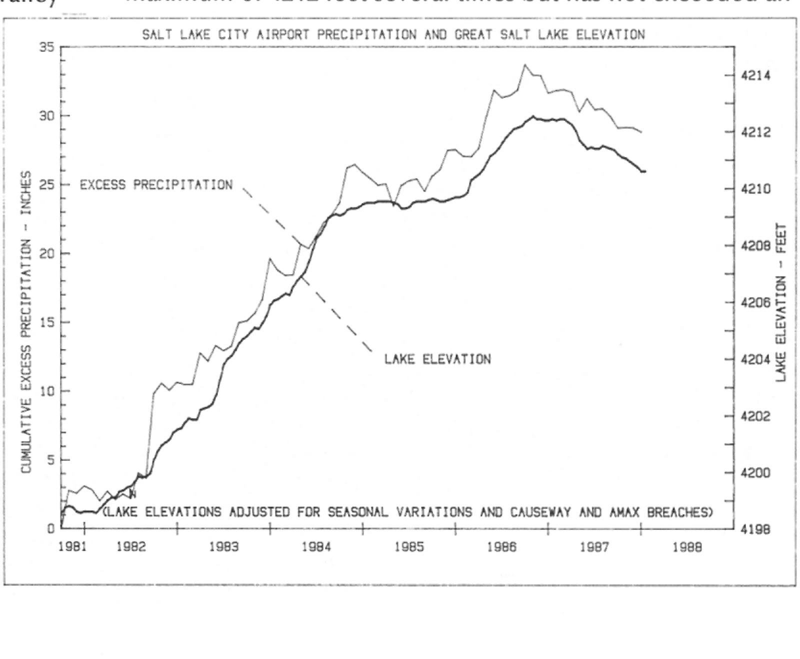
The 140-year record of weather observations in the area of Great Salt Lake define two major wet cycles about 115 years apart. The first was from 1866 through 1870 and the second was from 1982 through 1986 (Karl and Young, 1986). Although data on the earlier cycle are not as complete as for the later cycle, they appear to be comparable in length and amount of precipitation. The rise of Great Salt Lake during the two cycles was similar and the maximum elevation attained by the lake in each cycle appears to be identical.

In northwest Utah the annual precipitation ranges widely from less than 10 inches in the desert areas in the west to over 40 inches in the mountainous areas in the east. On the valley floor around the east shore of Great Salt Lake precipitation averages about 16 inches per year. In the wettest years over 25 inches of precipitation have fallen and in the driest about 8 inches.The Salt Lake International Airport with average annual precipitation of 15.7 inches is representative of the area around the east shore of the lake and in most years provides an indication of the percent of normal precipitation for the Great Salt Lake drainage basin.

As the terminal lake in a large drainage basin, Great Salt Lake is sensitive to major variations in precipitation in the region. When abnormally high or low precipitation persists for several years one result is a major change in the level of Great Salt Lake. The correlation of lake level rise with the 1980s wet cycle is illustrated by the combined plot of level of Great Salt Lake adjusted for seasonal variations and major dike breaches, and the cumulative excess precipitation at the Salt Lake City International Airport from 1982 through December 1987 (fig. 1).

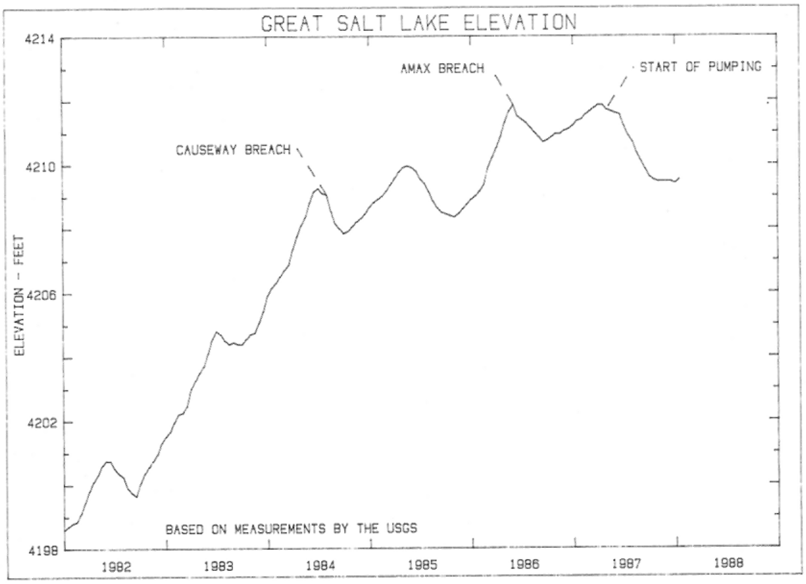
In historic time extended periods of below average precipitation have been more common and longer lasting than periods of above average precipitation, but the wet cycles are more dramatic departures from average. From 1928 to 1944 only two years had average or above precipitation. The cumulative result of this 17-year dry cycle was 42-inches of deficiency in precipitation and a six-foot decline in lake level (to 4196 ft). In one four-year interval, 1932-1935, the cumulative precipitation deficiency was 22 inches and the lake declined 4 feet. From 1952-1965 in only one year was precipitation above normal. The cumulative precipitation deficiency for these 14 years was 25 inches and the lake declined about 7 feet to an historic low (4194 ft) in 1963. During each of the five-year wet cycles in the 1860s and 1980s the cumulative excess precipitation was over 30 inches. The lake rise in the 1980s cycle was 11 feet. In the 1860s the lake is estimated to have risen 10 feet. Any comparisons of the lake level between the 1870s and 1980s must consider the effect of consumptive use on the lake level. Whitaker (1971) calculated that in the 1870s Great Salt Lake was about 2 feet lower than it would have been if no consumptive use had occurred. By 1965 this difference had increased to about 6 feet which corresponds to a volume deficit of about 4,400,000 acre-feet. A similar computation of the effect of consumptive use and other human activity on the level in 1987 has not been published but must exceed the 2 feet of the 1870s.

Geological and archeological evidence suggests that during the last 10,000 years Great Salt Lake has risen above the historic maximum of 4212 feet several times but has not exceeded an



elevation of about 4221 feet. Above an elevation of 4215 the lake under natural conditions expands into the Great Salt Lake Desert. In rising from 4215 feet to 4217 feet, the area of the lake increases an additional 550 square miles. At elevations between 4200 and 4212 feet each two-foot rise in the lake level results in an increase in lake area of about 125 square miles. When the lake rises from 4215 to 4220 feet, the area increases about 60 percent, to approximately 1200 square miles, which is about 2.4 times the area at the lake's historic average level of about 4202 feet. The increase in water loss from increased evaporation resulting from the expanded water surface area tends to stabilize the lake level. The West Desert Pumping Project artificially achieves what the lake would do naturally at approximately 4215 feet. To raise the level of Great Salt Lake above 4217 would require a wet cycle either significantly longer or more intense than any historic cycle. To raise the level above 4221 feet would require a major change in climate. Research on prehistoric lake levels will provide additional information on the prehistoric climate in the drainage basin of Great Salt Lake, particularly the wet cycles. Similar research on prehistoric climate will contribute to understanding the lake history.

The historic record of the climate in northwest Utah is only 140 years long and the prehistoric record is incomplete. Historic weather data and data on the prehistoric levels of Great Salt Lake suggest that wet cycles comparable to that experienced in the 1980s occur about once every 120 years and that wet cycles with much greater amounts of excess precipitation occur much less frequently. The UGMS recommends that the effects of wet cycles such as those in the 1860s and 1980s be considered in all planning decisions. More severe but less frequent wet cycles that cause Great Salt Lake to rise to levels from 4215 to 4217 feet should be considered in long term planning. No practical purpose will be served by planning for the major climatic changes that occur at intervals of once every 10,000 years or longer.



REFERENCES

Karl, T.R. and Young, P.J., 1986, Recent heavy precipitation in the vicinity of the Great Salt Lake: just how unusual: Journal of Climate and Applied Meteorology, v. 25, p 353-363.

Whitaker, G.L., 1971, Changes in the elevation of Great Salt Lake caused by man's activities in the drainage basin, *in* Geological Survey Research 1971: U.S. Geological Survey Professional Paper 750-D, p. D 187-189.

GREAT SALT LAKE LEVEL

Date (1987)	Boat Harbor South Arm (in feet)	Saline North Arm (in feet)
Sept 1	4210.10	4209.35
Sept15	4209.85	4209.10
Oct 1	4209.60	4208.80
Oct 15	4209.50	4208.70
Nov 1	4209.45	4208.65
Nov 15	4209.45	4208.65
Dec 1	4209.45	4208.65
Dec 15	4209.45	4208.65

Source: USGS provisional records.

Parapierrotite Discovered Near Lookout Pass

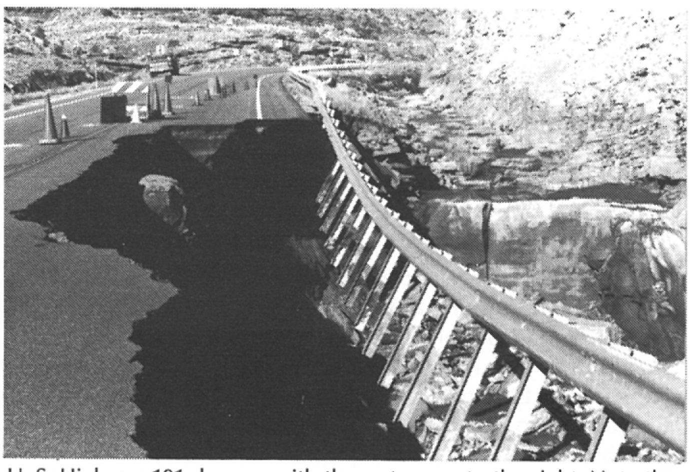
Two Utah prospectors, Robert and Terry Steele of Nephi, Utah discovered the mineral parapierrotite ($TlSb_5S_8$) near Lookout Pass in southeastern Tooele County while searching for disseminated gold mineralization. This is the first reported occurrence of the rare thallium-antimony sulfosalt in the United States. German mineralogists first discovered the mineral in 1975, near Allchar, in the Macedonia region of the Balkan Penninsula. Steve Axon of the U.S. Bureau of Mines Research Center in Salt Lake City identified the mineral using their state-of-art computerized x-ray diffraction equipment that automatically compares an unknown sample to a catalog of over 40,000 mineral patterns. The mineral resembles stibnite in hand sample and occurs as shiny, silver-gray, needle-like crystals arranged in radiating clusters as much as one inch in diameter. It is distinguished from stibnite by its lack of vertical striations and its purple-gray streak. Many of the grains are oxidized to a dull, light-yellow mineral that may be stibiconite. The mineral occurs in jasperoid (silicified limestone) pods that lie along north-south-trending fracture zones. Jasperoid boulders and outcrops weather to a rusty-brown to black color, easily distinguishable from fresh carbonate rock. While not of direct economic value, parapierrotite seems to be a good indicator for gold mineralization and will undoubtedly be of interest to mineral collectors.

AUGUST 7 FLASH FLOOD NEAR ARCHES NATIONAL PARK, UTAH

Paul Guardy, Superintendent, Arches National Park
William F. Case, Utah Geological & Mineral Survey

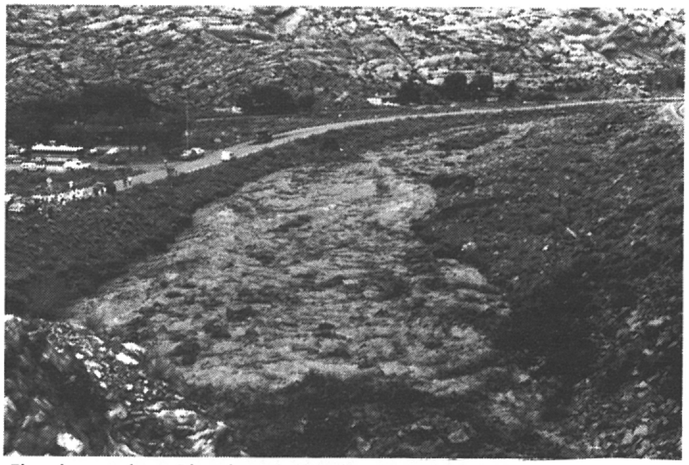
ON the 7th of August, 1987, at 6:00 p.m., a thunderstorm released a torrent of water which caused over $60,000 damage to the Moab Highway, U.S. Highway 191, and to a culvert entering Arches National Park, approximately 5 miles north of Moab, Utah. The National Weather Service River Forecast Group estimates that approximatley 0.75 inches fell from a solitary thundercloud in approximately one hour. The cloud was poised above the junction of the Dead Horse Point State Park/Canyonlands National Park road (Utah State Highway 313) and U.S. Highway 191. Several inches of water covered the highway junction area. During the same day, flood waters from a 0.7-inch-precipitation event reportedly overflowed a 6-foot culvert in a remote section of Castle Valley, approximately 30 miles to the southeast.

Two drainages received moisture from the thunderstorm. The largest, Courthouse Wash, carried most of the precipitation volume. The discharge from Courthouse Wash into the Colorado River was so great that the river was partially dammed and water in the river backed up to a depth of 3 feet at the confluence with Courthouse Wash. The wash was large enough to handle the precipitation flow without damage.



U. S. Highway 191 damage with the water gap to the right. Note the shallow channel which normally carries runoff without overflow (photo by Paul Guardy).

Bloody Mary Wash, with a total drainage area of only about six square miles, also received rainfall. The wash parallels U.S. Highway 191 from the junction with Highway 313 to the Colorado River, a few miles north of Moab. Bloody Mary Wash makes a severe bend as it enters Moab Canyon through a normally dry water gap in the cliffs near the Arches National Park visitor's center. A 1000-foot-long natural raceway eroded in a limestone member of the Pennsylvanian Hermosa Formation, constriction of flow, and a 15-20-foot drop at the water gap worked like a nozzle of a fire hose at the gap. Highway fill and the north lane of U.S. Highway 191 were eroded away as the water ran through the gap, swirled in a plunge pool, and deposited a boulder-bar directly downstream. The water faced one more barrier as it ran toward the Colorado. A culvert constructed by the Civilian Conservation Corps lies beneath the Arches National Park entrance road. The arched opening is about 20 feet square but could not carry the flow. Water backed up into a large pool, which slowed the flow and may have prevented further damage downstream. The culvert was partially undermined and suffered several thousand dollars damage. Water came within 6 inches of flooding the Arches National Park entrance road. Peak flow in Bloody Mary Wash was estimated to be approximately 54,000 cubic feet/second.



Flood water from Bloody Mary Wash going towards the culvert. Arches entrance road is on left (photo by Paul Guardy).

Flash flood waters coming through the Bloody Mary Wash water gap (photo by Paul Guardy).

UTAH EARTHQUAKE ACTIVITY
July through September 1987

Ethan D. Brown

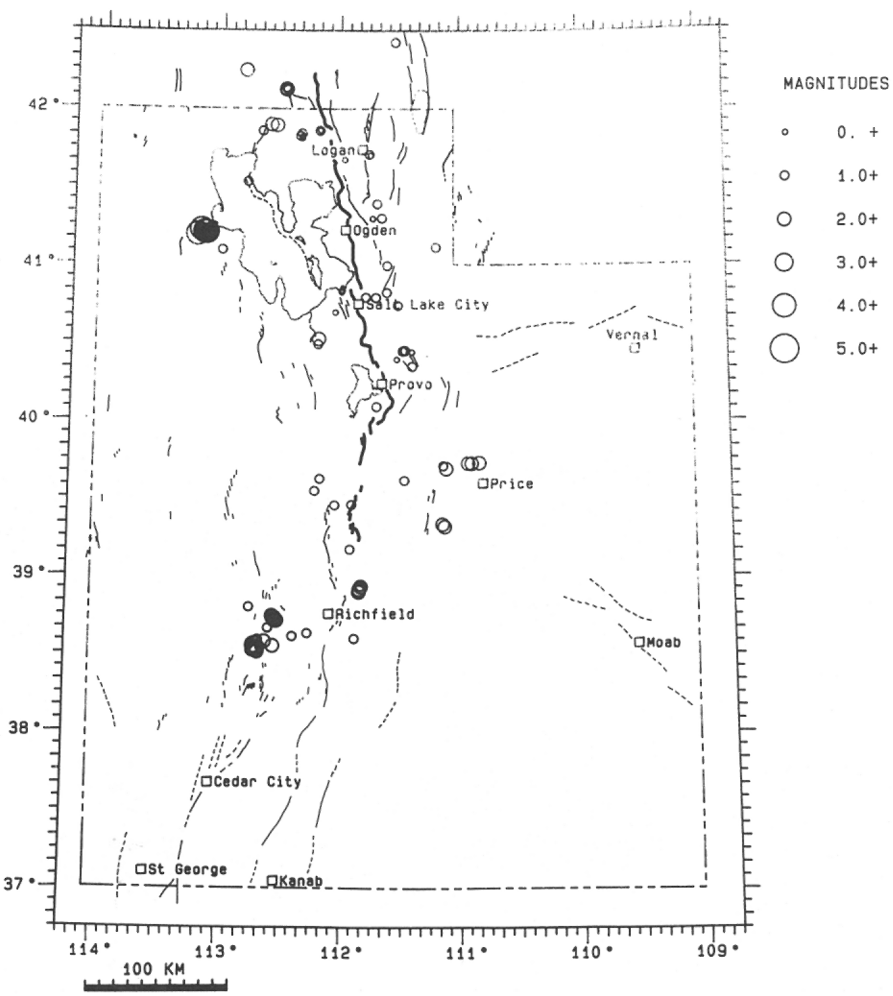
University of Utah Seismograph Stations
Department of Geology and Geophysics

The University of Utah Seismograph Stations records an 85-station seismic network designed for local earthquake monitoring within Utah, southeast Idaho, and western Wyoming. During July 1 to September 30, 1987, 130 earthquakes were located within the Utah region, including 49 greater than magnitude 2.0. The epicenters in Figure 1 show earthquake activity extending from south-central Utah northward through Utah's main seismic region to the Utah-Idaho border. Clusters of events occurred west of the Great Salt Lake, and 40 km southwest of Richfield, Utah. The largest earthquake, M_L 4.7 (UUSS; 4.9 USGS), during this time period occurred on September 25 (GMT) and was located 100 km west of Ogden and west of the Lake. This earthquake was reported felt from Wendover (on the Utah-Nevada border) to the Salt Lake Valley, and was the largest Utah earthquake since the 1975 M_L 6.0 Pocatello Valley event. The other felt earthquake in the report period was a small earthquake, M_L 1.7, on November 10 in the northeast Salt Lake Valley, which was felt in a localized area near the University of Utah.

Over half of the earthquakes during the report period were associated with two spatial clusters. The larger cluster, located west of the Great Salt Lake, contains 40 events including the M_L 4.7 earthquake on September 25. This sequence began on September 17 with an M_L 3.9 earthquake, and was continuing as of November 9, 1987. Four telemetered stations were deployed in the epicentral area to provide continuous data for detailed study.The cluster 40 km southwest of Richfield contains 30 events of $M_L \leq 3.4$. This cluster actually comprises two sequences about 20 km apart. The northern subset occurred during the last week of August. Activity then shifted to the southwest in early September and continued for about one week.

Additonal information on earthquakes within Utah is available from the University of Utah Seismograph Stations, Salt Lake City, Utah 84112; Telephone (801) 581-6274.

UTAH EARTHQUAKES
July 1 – September 30, 1987



N·E·W P·U·B·L·I·C·A·T·I·O·N·S

Miscellaneous Publications

M P 87-2, Mineral fuels and associated energy resources in Utah, by Martha R. Smith. An introduction to some natural materials useful for producing energy. This little brochure explains in layman terminology the uses and sources of Utah's energy resources, 1 page.

M P 87-4, Industrial commodities (non-metallic mineral resources) of Utah, by Martha R. Smith. A layman's brochure to introduce some of Utah's varied natural resources used in industrial applications, 1 page.

Open File Report

O F R 112, National Science Teachers Associaton Great Salt Lake field trip, by J. Wallace Gwynn, 5 pages, 1 plate. Field trip log with map for the southern part of The Great Salt Lake with emphasis on industry flooding.

O F R 113, Geologic map of Elephant Butte quadrangle, Kane County, Utah, by Hellmut H. Doelling, 20 pages, 2 plates, 1:24,000. An information release of the map as it begins the review and publication cycle. The area is SE of Zion National Park on the border of Arizona.

A N N O U N C E M E N T S

Other Publications of Interest

Former staff geologist, Karin E. Budding, and mapping geologist, Lehi F. Hintze, have recently had work published by the USGS.

U.S. Geological Survey Professional Paper 1354, Petrology and chemistry of the Joe Lott Tuff Member of the Mount Belknap Volcanics, Marysvale volcanic field, west-central Utah, by Karin E. Budding, Charles G. Cunningham, Robert A. Zielinski, Thomas A. Steven, and Charles R. Stern, and Miscellaneous Field Studies Map, MF-1950, Geologic map of the Mountain Home Pass and Miller Wash quadrangles, Millard and Beaver Counties, Utah, and Lincoln County, Nevada, by Lehi F. Hintze and Myron G. Best. Please contact the nearest USGS office for these items.

The USGS recently published Open-File Report 87-0154, "Proceedings of Conference XXXVIII; a workshop on earthquake hazards along the Wasatch Front, Utah " edited by W.W. Hays and P.L. Gori, 146 p. which contains articles of interest by several UGMS staff: Genevieve Atwood, W.R. Lund, D.R. Mabey.

Geological Society of America recently published Centennial Field Guide Volume (GSA-2) with an article by D.W. Moore, S.S. Oriel, and D.R. Mabey. Please contact GSA for this item.

NEW VOLUME IDENTIFIES OVER 500 REFERENCE SOURCES IN MINING AND MINERAL INDUSTRIES

Mining and Mineral Industries: an Information Sourcebook, contains the standard works of the mining and mineral industry. Included are the most recent reference volumes, periodicals, journals, and specialized nonprint materials. In addition, recommendations for basic reference collection are given to assist librarians in collection development and provide a listing of prime sources for new researchers.

The Oryx Press, 2214 North Central at Encanto, Phoenix, Arizona, 85004-1483

Call for Papers Issued for 1989 Rapid Excavation and Tunneling Conference

A call for papers has been issued for the Ninth Rapid Excavation and Tunneling Conference (RETC), June 11-15, 1989, Los Angeles, California. The **deadline** for submissions is **June 15, 1988.** The RETC is jointly sponsored by the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) and the American Society of Civil Engineers (ASCE). The Society of Mining Engineers of AIME is coordinating the technical program.

ITEMS OF INTEREST

Volcanology and Mineral Deposits

Sept. 18-23,1988	Fee: $675 includes two field trips
Topics:	Pryoclastic rocks---origins, facies concepts, vent areas; chronology and interrelation of igneous activity; mineralization and tectonism; geochemistry and geological setting of volcanic rocks; emphasis on exploration and evaluation.
Field trips to :	Tonapah and Goldfield, Nevada, districts; Long Valley Caldera, Bishop Tuff and Mono Craters, California.
Course Directors:	Harold F. Bonham, Jr., research geologist, Nevada Bureau of Mines and Geology; Donald C. Noble, professor of geology, Mackay School of Mines.

25th Annual Short Summer Courses

Powder Diffraction
June 20 to July 1, 1988

Two-week short course in modern powder diffraction will be offered at the State University of New York at Albany.

X-Ray Spectrometry
June 6-10, 13-17, August 15-19, 1988

The 25th annual short course in modern x-ray spectrometry will be offered at the State University of New York at Albany June 6 to 17 and August 15 to 19, 1988. The course is tutorial and covers the entire field of chemical analysis by means of x-ray spectrometry, from elementary principles to the latest, most sophisticated practices. The special 3rd week session in August will concentrate on mathematical and computer methods to solve the matrix problem and will probe further into the most in-depth problems of the advanced spectroscopist. Registration may be made for one week, each week, for $1,100.00 or for two weeks.

For further information and to register, write or call:
Professor Henry Chessin
State University of New York at Albany
Department of Physics
1400 Washington Avenue
Albany, NY 12222
(518)442-4512, 442-4513

Stanford School of Earth Science Allan H. James Memorial Fund

This fund, set up by the family of former Utah geologist and UGA president Allan James (1911-1985), has reached about half of its goal. To become self-sustaining, i.e., perpetuated by interest generated, it must reach $10,000 by year end.

The James family simply wants to let the world know that they will match any contributions. The contributions so kindly made last year can then be the start of a permanent fund to support student field projects, an area important for the perpetuation of our field of science.

Associate Dean Dudley Kenworthy, Department of Applied Earth Sciences, Stanford University, Stanford, Ca. 94305 is in charge of the fund, which is administered by Professor Marco Einaudi.

Congratulations!...

A Distinquished Service Award was given to *Roselyn Dechart* by the State Division of Risk Management for "outstanding accomplishments in property and liability loss control."

UGMS Staff Changes

Leigh MacManus has left the Editorial Staff for the California beaches. Her skill in creating Survey Notes and other UGMS publications will be missed.

Julia Vigil begins her time in Editorial with this issue of Survey Notes. Her speed in acquiring skills needed to handle two jobs during this period is both remarkable and appreciated.

As *Tandy Hedricks* went on to greener pastures, her half-time slot gave *Chris Wilkerson* the job as receptionist on a full-time basis. Her abilities and cheerfulness are a joy.

Wasatch Front County Geologists Retained

In 1985, the UGMS received a grant from the U.S. Geological Survey (USGS) to fund the Wasatch Front County Geologist Program. Funding was provided for five Wasatch Front counties (Weber, Davis, Salt Lake, Utah, Juab) to hire geologists on their planning staffs for a period of three years, with the UGMS providing assistance in hiring and technical supervision and support throughout the program. Three geologists were hired to cover the five counties, with Weber and Davis Counties and Utah and Juab Counties each sharing a geologist. The geologists were hired in June 1985, and funding expires in June 1988, at which time the counties must provide funding if they wish to retain the geologist. Much valuable work has been accomplished to date under this program, including compilation of maps showing geologic hazards areas, aid in writing and implementing ordinances addressing geologic hazards, and performance of engineering geologic studies as required for siting critical facilities, solving problems affecting public health, and monitoring and evaluating geologic hazard events.

The county geologists are a major component of the USGS and UGMS effort to reduce losses from geologic hazards in the Wasatch Front area, and it is very important that their work continue. The Wasatch Front counties involved in the program share in this commitment and have elected to fund the program beyond June 1988. Both Salt Lake and Utah-Juab Counties have hired the geologists as permanent merit employees on their planning staffs. Weber and Davis Counties have contracted with their geologist for the remainder of 1988 and will evaluate the possibility of permanent employment in the 1989 budget cycle. The UGMS is very pleased with the success of the program and the commitment of Wasatch Front counties to responsible land-use planning with respect to geologic hazards, and looks forward to continued involvement with the county geologists. ■

UGMS Asks for Geologic Proposals

The Utah Geological and Mineral Survey is requesting proposals for geologic projects which will encourage economic development of Utah's resources. Proposals are being solicited for specific geological projects from individuals, companies and universities.

The program is designed to meet some of the needs for the state for geologic information through contracting outside the UGMS. The Geological and Mineral Survey Director, Genevieve Atwood says, 'This is a creative way to call upon the expertise within the greater geologic community to add to UGMS' information data base for the citizens of Utah's benefit. This year, we are stressing projects that will be of economic benefit to the state.' Informal solicitation guidelines are available at UGMS. Specific inquiries should be directed to Doug Sprinkel, Deputy Director, Utah Geological and Mineral Survey, 606 Black Hawk Way, Salt Lake City, Utah 84108, 581-6831. The deadline for receiving proposals is March 18, 1988.

For further information contact: Dotti Brockbank, Public Affairs, 538-5508. ■

1988 Inventory Reduction Sale

The Utah Geological Association is having a 1988 inventory reduction sale on publications, March 21st through July 31st.
Most books are reduced 50% or more.
Also, get a set of 3 Uintah Basin and Uintah Mountains publications for $17.00, a set of 4 Overthrust publications for $30.00, or a set of all 15 UGA books (except the 1987 Guidebook) for only $100.00!
But don't forget about the latest — the 1987 Guidebook, ***"Cenozoic Geology of Western Utah,"*** which is available for $65.00 plus 10% postage and handling. Contact the Publication Desk of the Utah Geological and Mineral Survey for details and for orders.

UTAH DEPARTMENT OF NATURAL RESOURCES
Utah Geological and Mineral Survey
606 Black Hawk Way
Salt Lake City, Utah 84108-1280

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